temperature of 150℃ for 500 hours, the decrease in the tensile strength thereof was suppressed as compared to other lead-free solder alloy compositions.

[0019]

Hereinafter, with regard to the basic composition of Sn-Cu-Ni-Bi, a change in tensile strength resulting from a change in an additional amount of Bi will be described in detail. In more detail, it will be described based on the measurement result of a change in tensile strength of samples in which 0 mass% to 6 mass% of Bi are added to such composition.

Table 2 is a composition table showing compositions of the samples used in the measurement of the tensile strength.

As a Comparative Example (Sample i: Sample name is SN2), a composition of Sn-Cu-Ni to which Bi is not blended is contained. Further, the samples including Bi are referred to as Sample ii "Sample name: +0.1Bi*," Sample iii "Sample name: +0.5Bi*," Sample iv "Sample name: +1.0Bi*," Sample v "Sample name: +1.5Bi*," Sample vi "Sample name: +2.0Bi*," Sample vii "Sample name: +3.0Bi*," Sample viii "Sample name: +4.0Bi*," Sample ix "Sample name: +5.0Bi*," and Sample x "Sample name: +6.0Bi*." In Samples i to x, Bi is included in an amount of 0.1 mass%, 0.5 mass%, 1.0 mass%, 1.5 mass%, 2.0 mass%, 3.0 mass%, 4.0 mass%, 5.0 mass%, and 6.0 mass%, respectively.

[0020]

Samples i to x having the compositions in Table 2 were

TABLE 6

A (0 HOURS)	SAMPLE NAME	0.05Cu	0.1Cu	0.7Cu	2Cu	2.2Cu
	MEASUREMENT RESULT (Mpa)	46.4	46.6	51.6	61.2	60.2
C (500 HOURS)	SAMPLE NAME	0.05Cu	0.1Cu	0.7Cu	2Cu	2.2Cu
	MEASUREMENT RESULT (Mpa)	44.7	45.4	52.7	60.9	57.6
STRENGTH CHANGE RATE (C/A)	(%)	96%	97%	102%	100%	96%

[0042]

Table 6 is a table showing measurement results of the tensile strength of the samples having different additional amounts of Cu as described above. "A" of Table 6 is a measurement result of the tensile strength after the aging for 0 hours, and "C" of Table 4 is a measurement result of the tensile strength after the aging for 500 hours. Further, FIG. 4 is a graph summarizing the measurement results of the tensile strength of the samples having different additional amounts of Cu.

[0043]

All of "0.05Cu" to "2.2Cu" have a desirable strength change rate higher than 90% before and after the aging. However, since problems such as an increase in so-called Cu leaching may occur, it is not preferable that an additional amount of Cu is 0.05 mass%. Meanwhile, since problems such as a rise in liquid phase temperature, an occurrence of shrinkage cavity, or the like may

"SAC305," and ratios of the tensile strength of "SAC305" and Samples II to XIV to the tensile strength of Sample I, in percentage (%). In other words, Table 13 shows relative tensile strength with respect to "SAC305" and Sample I before and after the aging.

[0084]

TABLE 13

Alloy	BEFORE AGING		BEFORE AGING	
	COMPARISON WITH SAC305	COMPARISON WITH SN1+1.5Bi	COMPARISON WITH SAC305	COMPARISON WITH SN1+1.5Bi
SAC305	100	93	100	67
1.5Bi	107	100	148	100
0.001Ge	109	102	145	98
0.1Ge	123	115	149	100
0.1Sb	109	102	147	99
5Sb	134	125	181	122
0.1In	107	100	144	97
10In	140	131	137	93
0.001Ga	105	98	145	98
1Ga	130	121	202	136
0.005P	105	98	150	101
0.05Co	105	98	152	102
0.01Al	104	97	146	98
0.005Ti	109	102	152	103
1Ag	124	116	157	106

Unit: Mass%

[0085]

As can be seen from Table 13, all of Samples II to XIV have a relative tensile strength of 93% or more in both of before and after

WHAT IS CLAIMED IS:

[Claim 1]

A lead-free solder alloy, comprising:

76.0 to 99.5 mass% of Sn;

0.1 to 2.0 mass% of Cu;

0.01 to 0.5 mass% of Ni;

0.1 to 5.0 mass% of Bi; and

unavoidable impurities.

[Claim 2]

The lead-free solder alloy according to claim 1, wherein one or two or more selected from 0.1 to 5.0 mass% of Sb, 0.1 to 10.0 mass% of In, 0.001 to 1.0 mass% of Ge, and 0.001 to 1.0 mass% of Ga are added.

[Claim 3]

The lead-free solder alloy according to claim 1 or 2, wherein Bi is included in an amount of 0.5 to 4 mass%.

[Claim 4]

The lead-free solder alloy according to any one of claims 1 to 3, wherein Bi is included in an amount of 1 to 3 mass%.

[Claim 5]

The lead-free solder alloy according to any one of claims 1 to 4, wherein Ge is included in an amount of 0.001 to 0.1 mass%.

[Claim 6]

The lead-free solder alloy according to any one of claims 1 to

5, wherein In is included in an amount of 0.1 to 6 mass%.

[Claim 7]

The lead-free solder alloy according to any one of claims 1 to 6, further comprising: at least one of P, Co, Ti, Al, and Ag.

[Claim 8]

A soldered joint using the lead-free solder alloy according to any one of claims 1 to 7.

temperature of 150℃ for 500 hours, the decrease in the tensile strength thereof was suppressed as compared to other lead-free solder alloy compositions.

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Hereinafter, with regard to the basic composition of Sn-Cu-Ni-Bi, a change in tensile strength resulting from a change in an additional amount of Bi will be described in detail. In more detail, it will be described based on the measurement result of a change in tensile strength of samples in which 0 mass% to 6 mass% of Bi are added to such composition.

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[0084]

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Unit : Mass%

[0085]

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0.1 to 5.0 mass% of Bi;
0.001 to 1.0 mass% of Ge; and
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The lead-free solder alloy according to claim 1 or 2, wherein Bi is included in an amount of 0.5 to 4 mass%.

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The lead-free solder alloy according to any one of claims 1 to 3, wherein Bi is included in an amount of 1 to 3 mass%.

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The lead-free solder alloy according to any one of claims 1 to 4, wherein Ge is included in an amount of 0.001 to 0.1 mass%.

[Claim 6]

The lead-free solder alloy according to any one of claims 1 to 5, wherein In is included in an amount of 0.1 to 6 mass%.

[Claim 7]

The lead-free solder alloy according to any one of claims 1 to 6, further comprising: at least one of P, Co, Ti, Al, and Ag.

[Claim 8]

A soldered joint using the lead-free solder alloy according to any one of claims 1 to 7.